CRN: 32908

School of Science, Engineering and Environment

TRIMESTER TWO EXAMINATION

PROGRAMMES:
MSc Transport Engineering & Planning

TRAFFIC ENGINEERING: ANALYSIS & ROAD SAFETY P1

Wednesday 13th May 2020 **10:00 – 13:00**

<u>Instructions to Candidates</u>

Time allowed 3 hours.

There are FIVE questions.

Answer **THREE** questions from Section A. Section B is compulsory (i.e. a total of **FOUR** questions).

All questions carry equal marks. The percentage allocation of marks within each question is as indicated.

State any necessary assumptions.

Calculators may be used but **NOT** in text storage mode.

Exam paper should be submitted together with the answer book.

Students must not remove this exam paper from the venue.

SECTION A (Answer THREE questions from this Section)

1. Junction capacity analysis

a) With reference to a major/minor priority junction, discuss the analytical approach to predicting capacity. In your answer you should describe the critical variables which determine the capacity, outline any related statistical distributions and explain the gap acceptance process which is at the heart of the model.

(35 marks)

b) Compare the analytical approach to predicting capacity and delay at a major/minor priority junction with an empirical approach based on observations derived from case study sites. Include reference to strengths and weaknesses of each approach in your answer.

(25 marks)

c) A major/minor priority controlled T-junction in an urban area has arms A, B and C labelled clockwise with B as the minor arm. Average existing peak hour flows at the junction are as shown in Table 1. A new development is being considered on Arm B. Comment on the congestion likely to occur at this junction for stream B-C, when the development becomes fully operational in five years time.

Table 1 - Existing peak hour traffic flows (pcu's/h)

	To		
From	**A**	**B**	**C**
A	0	250	500
B	100	0	325
C	200	50	0

Assume that:

Annual traffic growth is *2%*.
The multiplier to represent short-term variations in the traffic flow profile is 1.125.
Additional peak hour traffic flows arising from the development in the design year (that is, in five years time) are:

B – A = 60 *pcu's/h*
B – C = 75 *pcu's/h*
A – B = 60 *pcu's/h*
C – B = 75 *pcu's/h*

The flow profile for the development traffic is expected to be constant during the hour.

$$q_s = 720 - 0.70(0.364q_{A\text{-}C} + 0.144q_{A\text{-}B})$$

where

q_s = capacity of stream B-C (*pcu's/h*)
$q_{A\text{-}C}$ = design flow of stream A-C (*pcu's/h*)
$q_{A\text{-}B}$ = design flow of stream A-B (*pcu's/h*)

(40 marks)

2. Traffic signals

a) Explain clearly what is meant by the term ‘lost time’ in traffic signal design, noting the individual elements of ‘lost time’ which exist in the cycle.

(15 marks)

b) Define clearly what is meant by the term ‘intergreen’ and explain its importance to the safety of road users at the junction. Include reference to the calculation of minimum intergreen values in your answer.

(15 marks)

c) Figure 2 shows an isolated staggered junction controlled by traffic signals working under vehicle actuation. Demand flows and saturation flows are given in Table 2.

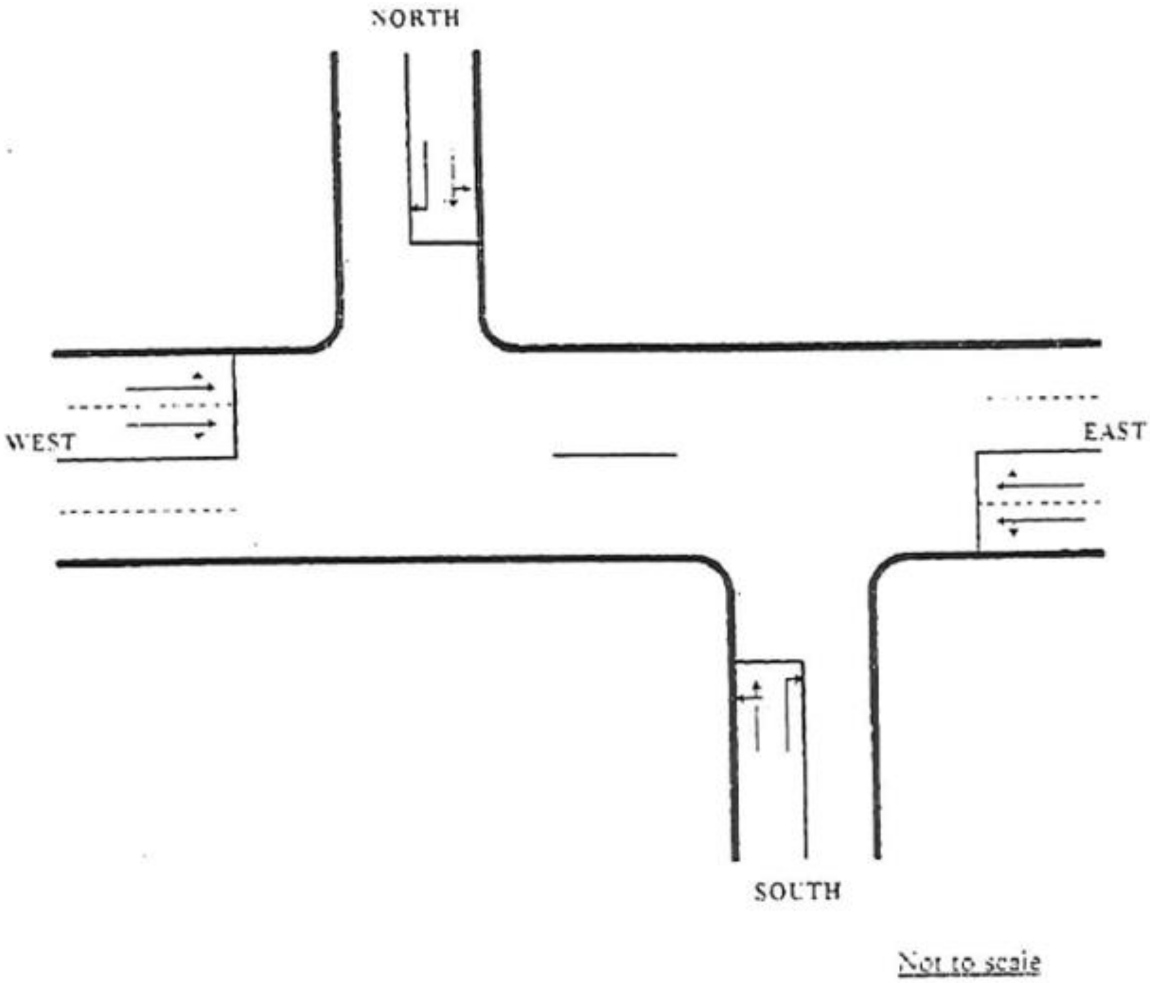

Figure 2 – Staggered traffic-controlled junction

Table 2 - Existing peak hour traffic flows (*pcu's/h*)

Stream Number	Stream description	Demand Flow (*pcu/h*)	Saturation Flow (*pcu/h*)
1	All traffic approaching from the West	1200	4000
2	Traffic from North to West	300	1650
3	Traffic from North to South and East	530	1800
4	All traffic approaching from the East	1000	4000
5	Traffic from South to East	210	1650
6	Traffic from South to North and West	180	1800

Two possible stage arrangement for the junction are being considered as follows:

<u>Alternative A</u>
Stage 1 = streams 1 and 4
Stage 2 = streams 2 and 3
Stage 3 = streams 5 and 6

<u>Alternative B</u>
Stage 1 = streams 1 and 4
Stage 2 = streams 3 and 6
Stage 3 = streams 2 and 5

i) Calculate the optimal cycle times and degrees of saturation for each stream for each alternative and compare the alternative stage arrangements, given that total lost time per cycle is 15 *seconds* in each case.

(55 marks)

ii) Assuming Alternative A is preferred, give reasons why a shorter cycle time than calculated in part *i)* may be chosen in practice.

(15 marks)

3. Traffic flow theory (queuing theory/car following models)

a) Illustrate in a sketch (with a brief explanation) how queue length varies with traffic intensity for both the "steady state theory" and the "deterministic theory". ***(25 marks)***

b) The "2 seconds" and the "2 white markers (chevrons)" techniques are used to describe the law-obeying car following rules on motorways.

i) Briefly describe the two techniques and explain how these techniques are different from each other.

(25 marks)

ii) Derive the theoretical speed/flow relationships for both of the above techniques making any necessary assumptions and using appropriate sketches to show the relationships.

(25 marks)

iii) If a similar technique to that using "chevrons" on motorways was adopted on a dual carriageway road with a speed limit of 50 *mph*, what distance would be required between successive chevrons in order to achieve a capacity of 1000 *veh/h/lane*?

(25 marks)

4. Traffic flow theory (speed/flow/density relationship)

As part of a two-lane (one-way) carriageway, there is a 0.3 *km* long tunnel which has a restricted capacity of *1700 veh/h/lane*. The maximum flow per lane on the unrestricted section of carriageway prior to the tunnel is 2200 *veh/h*. When stationary, vehicles are spaced at average distance headways of 7.5 *metres*. It may be assumed that there is a linear relationship between speed and density.

a) From first principles, derive the relationship representing capacity in terms of free speed and jam density.

(25marks)

b) When the traffic flow approaching the tunnel is 4000 *veh*/h, calculate:

i) the speed of the traffic stream a considerable distance in advance of the bottleneck

(35 marks)

ii) the speed of the traffic stream immediately before the commencement of the bottleneck

(20 marks)

iii) the speed of the shockwave formed by the bottleneck.

(20 marks)

SECTION B (This question is compulsory)

5. Speed management and control and its impact on road safety

a) Drawing on literature including Mitchell, (2012) or equivalent items, describe and comment on the association between speed and safety in urban areas.

(35 marks)

b) Discuss the use of speed limits as an accident reduction measure.

(40 marks)

c) Describe and review how changes to the horizontal alignment of residential roads could be used to support a 20*mph* zone.

(25 marks)